

A STUDY OF INFECTION OF THE KNEE-JOINT BASED UPON AN ANALYSIS OF 310 CASES.

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INFECTION in any wound presumed to be clean is a source of chagrin. The discomfort is somewhat modified by the possibilities in the individual case, but infection in certain regions is always looked upon with veritable horror. One of these regions is the knee-joint. Every surgeon has a clear conception of this calamity, and so pronounced is the impression universally, that there can be no doubt that many joints which might be opened to advantage are left untouched. We have investigated the subject for the purpose of determining, if possible, which cases are responsible for this general attitude, and to ascertain whether in the light of modern surgical technique this aversion is justified in all cases.

Fortunately and unfortunately, one's experience with infection of the knee is relatively small. Fortunately for evident reasons, unfortunately because much of value cannot be known as a matter of personal experience, but must be accepted as applying to scattered cases observed by different men.

During the last eighteen months the writer has endeavored to collect such data as would seem to bear upon this subject, and has examined the records of all cases available to him.

I am indebted to many surgeons in New York for allowing me to use their hospital cases in connection with my personal operations upon the knee, and, inasmuch as the cases were taken "as they came" in the records during the last ten years, it would seem reasonable to assume that the data obtained represent more nearly the actual state of affairs than would a similar collection of cases from literature.

Tuberculous, gonorrhœal knees and those occurring in

connection with osteomyelitis of the tibia and femur are not considered, only such as were operated for what is commonly termed "surgical infection." It may perhaps with justice be claimed that there is no reason for excluding the cases secondary to osteomyelitis, but the combination of osteomyelitis of the bones and knee-joint infection is such a vicious picture that the final results influence any conclusions all out of proportion. The condition is so disastrous as to be better treated by itself.

Comparatively few cases were investigated from a bacteriological stand-point,—evidently because the information derived would not have altered the course of treatment in the individual case. There is still much of value to be learned from more accurate knowledge of the bacteriology of knees which present all the cardinal signs and symptoms of infection.

Infection occurred in five groups of cases:

- a.* Clean knees operated.
- b.* Penetrating wounds of the knee-joint.
- c.* Primary in the knee without evident port of entrance.
- d.* In the course of evident infections elsewhere.
- e.* Following some trauma (non-penetrating).

Before entering upon a discussion of such cases as were operated because of the infection, let us examine the cases coming under any one of these five headings which did not seem to demand operation, and define our position with reference to the term infection. By infection we mean the entrance of bacteria into the joint, which event is followed by the cardinal signs and symptoms of such infection,—redness, pain, heat, loss of function, temperature, rise of pulse, etc. It is unnecessary to state that these cardinal signs and symptoms may be present to any degree. The presence or absence of pus is not considered. Pus is a vague term to be classified with such indefinite expressions as "fungus," for instance. There has grown up the idea that whenever this cloudy fluid which we call pus is found, the containing cavity should be opened as extensively as possible. This is a blind method of procedure, which cannot be made to apply universally, however appropriate in the vast majority of cases. Everybody knows

that certain pus cavities will heal after aspiration, and we prefer this method when conditions allow because of the danger of secondary infection. The relation between the character of the infected fluid in a knee-joint and the patient's power of resistance as indicated by the cardinal signs and symptoms of infection is our guide for operating. A knee-joint may contain creamy pus with very few signs and symptoms. This joint would better be aspirated and treated, as certain inguinal and tuberculous abscesses, rather than open freely and expose to all sorts of contamination. Not pus, but the character of the contained infected fluid is our guide for free openings.

It is common occurrence to obtain a negative bacteriological report from abscess cavities, yet nobody questions the infectious origin of the trouble. This applies also to the knee-joint. That the knee-joint exercises a certain amount of germicidal power as we should expect can be demonstrated in the following manner. When operating upon a knee with an excess of synovial fluid, first aspirate into a clean cover dish; on opening the joint, uncover this dish and one containing gelatin or agar. Cover them at the end of the operation and place in an incubator. Both will be found to contain colonies. The fluid in the joint is again aspirated on the day the cultures are investigated, examined immediately and placed in a cover dish. Both examinations will prove negative in cases we consider clean. There is no reason to suppose the air immediately over the field of operation was any cleaner than that over the two dishes. If more knees were examined in this way, we should be in a better position to state what the bacteriological condition of many knees were which show postoperative signs and symptoms not to be distinguished from those produced by infection.

Again, we have the knee presenting cardinal signs and symptoms of infection, yet on aspiration the joint fluid is sterile. These are supposed to be due to toxins secondary to some infection elsewhere in the body which may or may not be apparent. How many of these knees are really due to this

ascribed cause will only be known when we have more information regarding the milder cases of bacterial infection which recover without open operation.

Every surgeon has regarded with anxiety the signs and symptoms arising after an operation upon the knee and in cases of penetrating injury to the joint. The cardinal signs of inflammation are all there, but not sufficiently marked to demand reopening the joint. The symptoms gradually subside, the knee recovers. There can be absolutely no question that certain of these joints are mildly infected.

Another group, the last, which may present these cardinal signs are the non-penetrating traumatic knees. Almost every severe injury to the knee presents these signs to some degree; yet we do not worry; the joint is not open, and we know that infection otherwise than through a wound is rare. Still, this can happen, as we shall see later, and in the absence of bacterial proof we cannot claim that even some of these knees are not infected.

There is one point, however, which attracts attention. Non-penetrating injuries to the joint rarely show signs and symptoms for any length of time; whereas in penetrating wounds, whether operative or traumatic, the symptoms continue for several days up to weeks. It does not seem reasonable to assume that the penetrating nature of the wound should be made responsible for this difference in the clinical picture. We prefer to consider that many of the penetrating cases are infected.

A late examination in any one of these five classes does not enable us to state what was the primary cause of the functional disability. The same condition may be secondary to trauma, bacterial infection, or irritation from toxins. Our only guide would be a bacteriological investigation at the time of the primary difficulty; and, although made in scattered cases, the number we have is not sufficient to warrant any more definite statement than the above.

Joints belonging to the rheumatic group have not been considered.

The fact that there are cases belonging to each of the above five groups which do become so bad as to demand operation, and the fact that bacteriological proof does exist in certain of these cases, is evidence sufficient that all of these joints do at times become severely infected. It is not reasonable to assume that when infection does occur it is always severe. Mild cases must also exist; the above mentioned unknown quantity, *i.e.*, the relation between power of resistance and character of infection, alone determining the nature of the clinical picture.

The situation is quite different when we consider the cases which have been operated because of infection. Here the data at hand, although not complete, are sufficiently accurate for clinical purposes to allow of deductions regarding the frequency of infection of the knee and the final outcome of such cases. Of 237 clean knees operated, 11 became infected and were subsequently reopened. This means that approximately one out of every 21 to 22 operations upon clean knees becomes sufficiently infected to demand opening and draining the joint, *i.e.*, 4.6 per cent. If we investigate to determine what the immediate outcome of such infection is we find that one case came to amputation, *i.e.*, 9 per cent. of the infected cases, and that the stay in the hospital was from one to six months, the average being three months and ten days. This does not mean that the patients were all well on discharge. Many had sinuses. It would not be of any value to say what percentage, because of the uncertainty of the data obtained on this point. Many were discharged with varying degrees of functional disability, from slight limitation of motion to complete ankylosis, with some subluxation in a few cases.

On examining these septic cases somewhat more closely, we find that in 8 of the 11 the primary reason for interfering was some recent trauma, and that in only 3 was the operative indication some other pathological condition. This means that of clean operative cases which become infected, about 7.3 per cent. are traumatic cases primarily and only 27 per cent. of pathological origin. The total number of traumatic cases

operated before the fifth day was 66, seven of which became infected, *i.e.*, about 11 per cent.

The total number of non-traumatic cases and traumatic cases operated after the fifth day was 141 with four infections, *i.e.*, one out of every 35, or about 2.9 per cent.

The total number of non-traumatic pathological cases (loose cartilage, foreign bodies, chronic synovitis, etc.) was 70, with three infections, *i.e.*, one out of 23, or about 4 per cent.

In 28 cases the time data could not be obtained.

The fracture of the patella group is largest and perhaps of greatest interest. Of 150 simple fractures of the patella operated, seven became infected and demanded subsequent operation, *i.e.*, one out of every 21 to 22, or about 4.66 per cent. The other groups are represented by so few cases comparatively, that no statistical representation of value could be brought forward. Of the septic patellæ, one was operated four hours after injury, four on the second day, one on the third day, and one after some months. In 128 of the 150 cases of operated fractures of the patella, the time elapsed between the injury and the operation could be determined. In 71 of these it was five days or more, in the remaining 57 it was under five days. Of the cases operated on after the fifth day one became sufficiently infected to demand operation; of the 57 operated on before the fifth day, six became infected. Provided the time elapsed between injury and operation in the 22 cases where the data are insufficient is in the same ratio as in the 128 cases where the time is given, the percentage of simple fractured patella operated after the fifth day which become infected, is about 1.2 per cent., whereas of the cases operated before the fifth day, 8.9 per cent. become sufficiently infected to demand reopening the joint. This would seem to indicate that in this region operating in bruised, lacerated tissue before active repair processes are well established is about eight times more liable to be followed by infection than when operating after a delay of five days, which corresponds in kind with experience in traumatic surgery elsewhere in the body.

The next group consists of the infections in penetrating traumatic wounds. The data obtained here are such as to make us always look upon an accident of this sort with anxiety.

Of 52 penetrating traumatic wounds, 30 became sufficiently infected to demand secondary operation. These were: lacerated wounds 19; punctured wounds, 8; 1 compound wound of joint with small piece of condyle broken off, infected; 3 gunshot wounds, with two infections. This means that three out of five, or about 60 per cent., of all penetrating wounds of the knee-joint become severely infected. The numbers in the individual groups are so small as to preclude deductions; but if the lacerated and punctured wounds be considered together, it is found that 20 out of 39 were infected, *i.e.*, about 50 per cent.; and if the compound fractures of the patella be examined separately, it will be seen that seven out of nine became infected, *i.e.*, about 78 per cent.

The immediate outcome of these penetrating infected wounds is as follows: Of 30 cases, four died with or without previous amputation, two legs were amputated, and two knees resected. Of the remaining 22, two were removed from the hospital against advice, while 20 were discharged sooner or later with a varying amount of disability. Four of these had complete ankylosis on leaving the hospital. The stay in the hospital varied from five days to six months and two weeks, the average being two months and three weeks. This is somewhat less than the average for operations upon clean knees which become infected, due possibly to the fact that three of the fatal cases were in the ward less than one week. All of which means that one out of every thirteen penetrating traumatic injuries to the knee-joint died, *i.e.*, a death-rate of 7 to 8 per cent., and one of every seven to eight of the infected cases dies, *i.e.*, a death-rate of 13.3 per cent. One out of every 26 cases of penetrating traumatic wound to this joint comes to amputation, *i.e.*, 3 to 4 per cent., and 1 in 15 of the infected cases comes to amputation, *i.e.*, 6 to 7 per cent.

We next consider the cases which become infected suffi-

ciently to demand operation after some known injury to the joint. These cases were not operated for the trauma. Of these we have been able to collect six. The injuries were: One horse-kick, two blows, two falls, one run over and knee twisted. In none of these was the joint opened. The signs of infection became sufficient to demand operation on the fourth, fifth, seventh, tenth, and twenty-first day. One case died, one came to amputation. The other four were discharged with a varying amount of disability. These cases stayed in the house, with the exception of one case leaving against advice, from five days to five months and two weeks, the average being two months. The infection must have occurred much in the same way as in acute osteomyelitis after injury.

The next group of cases includes those infected knees where no history of trauma or evident focus of infection elsewhere could be found. There are eight cases. One died after amputation, the rest were discharged with varying degrees of functional disability. It is a curious fact that each and every history in this group, taken by different men at different times, points out that the onset was sudden, sometimes with chill. The time elapse between onset and operation varied from ten days to six weeks, the average being three weeks and five days. There were three males and five females. A bacteriological examination made in six cases showed "coeci" and denies gonococci. We know that other bacteria besides the ordinary coeci can infect joints, especially the pneumococcus; but, inasmuch as all of these patients were between eighteen and forty years,—the gonorrhœal age, as it were,—five being twenty-five or under; and considering the fact that five were females, not apt to be questioned or examined too closely, a quite unusual preponderance compared with the sex ratio in the other groups, it would seem to me that some of these bacteria might possibly have been gonococci.

The last small group of cases represents those infected knees occurring in the course of some evident infection elsewhere or immediately after such infection. The conditions in connection with which these joints appeared are as follows:

Multiple boils, one case; severe bronchitis, one case; excision of gumma of thigh, one case; cholecystitis, one case; septic uterus, one case; inguinal adenitis following septic focus on foot, two cases; seven cases in all. One case died, the rest discharged. The knee symptoms appeared from the second to the twenty-third day after the onset of the first septic process. Unfortunately, there is no bacterial proof that the two processes were caused by the same bacterium. In three cases "cocci" were found in the joint, but in the remaining four there is nothing to prove that the conditions might not belong to the group of cases supposed to be caused by the irritation of toxins or by an independent infection.

If all of these septic cases be considered together, we have sixty-two infections sufficient to demand operation. Of these seven died, *i.e.*, about one in nine, or about 11 per cent.; four came to amputation, *i.e.*, one in fifteen, or about 6.6 per cent.; two were resected, *i.e.*, 3.3 per cent., and 49 recovered, *i.e.*, about 76 per cent., with functional disability varying from slight limitation of motion to complete ankylosis. The average stay in the hospital was between two and three months (ten and one-half weeks).

In searching for data which might aid us to treat these severe infections more successfully, we find little that is to guide us. There are numerous knees evidently infected which are never opened or reopened; still, they recover with varying subsequent disability. As already mentioned, the bacteriological information which would enable us to interpret many of the conditions is absent except in individual cases. At the present time, a knee-joint is reopened only when the combination of signs and symptoms is such as render it beyond question that we have to deal with an extreme condition. The final outcome is well indicated by the above remarks. Had we more definite information regarding the early stages of these severe conditions, and were we able to distinguish from joints, which, although presenting similar signs and symptoms, were not apt to run so vicious a course, we would be in a posi-

tion to attack the severe infections earlier and perhaps improve the outlook.

If a joint is to be opened and drained at all, the first operation should be radical. If open operation is necessary, it is necessary to be extreme. This is plainly shown by the fact that many of the knees operated for infection were reoperated at some later date to get increased drainage. This should have been done in the first place, not after conditions are worse and the chance of favorable termination so much less. Of the seven fatal cases four were opened and reopened. Not that this is proof that an early more radical procedure would have changed the final outcome. The ever unknown relation between power of resistance and strength of infection prohibits such a deduction. But considering the possibilities, the extreme should be done at first to get the maximum amount of good at once.

Most cases are irrigated with some antiseptic. There is a happy medium between the amount of good done by an antiseptic and the amount of harm done to tissues. There is no question that carbolic and bichloride of mercury do destroy cells and diminish the function of others. Still, we do not feel that clinical evidence allows us to join the ranks of those who would discard these agents entirely for a purely mechanical cleansing agent, such as salt solution. We do not feel that the damage done to cells and their function is greater than the good derived from attenuating the virulence of the offending bacterium by the occasional use of some antiseptic. If we could, we would sterilize the entire cavity, cauterize it, and dress it aseptically as it were, to leave the process of healing to take care of the sterile dead tissue. For evident reasons this is not practical, and we believe that it is best to do the next thing, sterilize little by little with some antiseptic fluid and leave the body to replace the damaged cells. There are cases which go from bad to worse in spite of any cleansing agent or antiseptic, but we cannot believe that the process extended because of the use of an antiseptic which diminishes at least the virulence of the parasite.

In less acute cases the leg should have continual traction to prevent subluxation.

Every infected knee is a huge abscess cavity with many pockets hard to drain. Any anterior incision can but poorly serve the purpose at best. We drain the top of the abscess but not the parts behind, neither do we drain any bursa which may happen to communicate with the joint. The bursa near the semimembranosus is the most often troublesome. It is our opinion that it is much better to keep these unfortunate people on their faces as much as possible, after making liberal drainage openings. If there are infected bursæ, these should always be opened. Various incisions have been used in the above cases, from complete transverse division to multiple openings front and back. Mildly infected joints, with moderate signs of infection where one is still in doubt as to the advisability of free open incision, should be treated as a synovitis by repeated aspirations. Certain joints will recover under this form of treatment even when the fluid withdrawn is very cloudy. It is the character of the fluid, not its macroscopic appearance, which is of importance. Should, however, the clinical signs indicate that the infection was progressing, then the utmost in the way of open operation should be done at once.

These figures represent the average conditions.

To summarize, let us say:

Non-penetrating injuries, penetrating injuries traumatic or operative and knees independent of any injury in the course of some other infectious process or not, may present signs and symptoms not to be distinguished in the absence of bacteriological examination from the cardinal signs and symptoms of infection.

Certain of these cases are undoubtedly infected, but the data at our command do not allow us to distinguish these from such as may be due to trauma and those possibly due to toxins secondary to infection elsewhere.

The knee-joint has certain germicidal powers.

One out of every 22 operations upon clean knees becomes sufficiently infected to demand operation (4.6 per cent.).

One out of every 9 operations for recent (5 days) traumatic non-penetrating injury becomes sufficiently infected to demand operation (11 per cent.).

One out of every 35 operations for pathological conditions other than traumatic injuries more than five days old becomes sufficiently infected to demand operation and draining the joint (2.9 per cent.).

One out of every 22 operations for simple fracture of the patella becomes sufficiently infected to demand operation (4.6 per cent.).

One out of every 71 operations for fracture of the patella done after the fifth day becomes sufficiently infected to demand operation (1.2 per cent.).

One out of every 9 to 10 operations for fracture of the patella done before the fifth day becomes sufficiently infected to demand operation (10.5 per cent.).

Three out of every five cases of penetrating injury to the knee-joint become sufficiently infected to demand operation (60 per cent.).

Of compound fractures of the patella, seven out of nine become sufficiently infected to demand operation (78 per cent.).

Certain knees subjected to non-penetrating injury and not operated become sufficiently infected to demand operation (10 per cent. of the operated septic cases).

Certain knees become sufficiently infected to demand operation where no history of trauma exists or other evident septic focus in the body (13 per cent. of the operated septic cases).

Certain knees become sufficiently infected to demand opening and draining the joint in the course of some evident focus of infection elsewhere in the body (11 per cent. of the operated septic cases).

One out of every nine infected knees which have been opened and drained dies (11 per cent.; some after previous amputation).

One out of every fifteen infected knees which have been

opened and drained comes to amputation before recovery (6.6 per cent.).

One out of every thirty-one infected knees which have been opened and drained is resected (3.3 per cent.).

Most knee-joints which have been infected, opened, drained, and recovered show varying degrees of functional disability, from slight limitation of motion to complete ankylosis with or without subluxation.

The average stay in the hospital of an operated infected knee-joint is between two and three months.

When it is once determined to open and drain a knee-joint, the operation should be as radical as possible at the start.

The position of the leg should be that giving the best mechanical drainage, *i.e.*, the patient should be face down.

The risk of infection is greatest in penetrating wounds of the knee (60 per cent.).

The risk of infection is least in operations upon clean knees and where there has been no recent trauma (3 to 4 per cent.).